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COVER

This high oblique of Fort Rucker was taken by 1st Lt Virgil R. Rogers, U. S. Army Signal Aviation Test and Support Detachment, (USASATSD), with a hand-held K-20 drone camera being tested for use in fixed wing aircraft. Once the camera is turned on, it automatically takes a picture every 3.2 seconds. Since this camera was designed for use in a drone, it has no sighting device, making the assignment much more difficult.

Notes from the Pentagon

Carbon Monoxide as It Affects the Aviator

Brigadier General Ernest F. Easterbrook, *USA*
Director of Army Aviation, ODCSOPS

IN OCTOBER 1956 an Army aircraft crashed shortly after takeoff. The cause was not known until the medical investigation had been completed. Autopsy disclosed that the occupant of the front seat had an 8 percent saturation of carbon monoxide and the occupant of the rear seat had a 38 percent saturation. This was the first of several accidents attributed to carbon monoxide poisoning during FY 1956. There is a possibility that many such accidents in the past have been labeled "Cause Unknown."

Contamination of the cockpit with carbon monoxide is an ever-present danger when flying aircraft powered with internal combustion engines. The dangerous aspects of this gas are well known through published reports of accidents and suicides associated with automobiles. In order to understand the significance of carbon monoxide relative to the pilot, we will consider the following points:

1. The sources on aircraft.
2. The reaction on the body and the manner in which it is absorbed.
3. The absorption of carbon monoxide by the blood in relation to: The amount in the air; the length of exposure; the amount of physical activity.
4. Human behavior while under its effects.

The sources by which carbon monoxide will most likely penetrate the cockpit are:

1. The powerplant (primary source).
2. Faulty internal combustion heaters.
3. Defects in the heat exchangers and firewalls.

4. Improper design location of air scoops of the ventilating system.

5. Wing passages or openings in the fuselage by the exhaust.

Carbon monoxide is not a true poison, but because of its greater attraction to the red blood cells (the oxygen carrier of the blood) it interferes with the transport of oxygen to the tissues. It is estimated that only 1/210 times as high a concentration of carbon monoxide as of oxygen is required to saturate a given number of red blood cells. When this gas is competing with oxygen the odds are 210 to 1 in its favor. A very small concentration of carbon monoxide can combine with the red blood cells to produce symptoms of an acute oxygen want.

The absorption of carbon monoxide by the blood depends upon the concentration, exposure time, and rate or depth of breathing. If you are engaged in physical exercise, a larger volume of blood will be exposed in the lungs in a given time. Exposure to moderate concentrations of carbon monoxide in the air (about 0.02 percent) results in the onset of symptoms within 2 or 3 hours.

The effects of this gas on human behavior are similar to those of high altitude. The chief danger is that they are insidious, usually of gradual onset, and often difficult to detect. The first indication may be a headache; more advanced stages are characterized by dizziness, nausea and weakness. Your reactions are decreased ability to attend to details, increased irritability, and forgetfulness. These indications are similar to those of alcoholism.

Excessive smoking before a flight will influence your tolerance during flight. About 1 to 2.5 percent of the total volume of the smoke of a cigarette is carbon monoxide. The content in cigar smoke is even higher. Inhalation of the smoke from a single cigarette will cause an increase of almost 2 percent in the saturation of the blood with carbon monoxide. You should not smoke a cigarette within 45 minutes of your landing time.

The role of the Aviation Medical Officer in accident investigation is making great contributions to the accident prevention program. As a result of the above accident a TWX was dispatched worldwide warning pilots of the danger of carbon monoxide and recommending that heaters, exhausts, and all connections be checked for defects.

Avoid the danger of carbon monoxide by close inspection of your aircraft.

Army Aviation Safety Course Stresses Accident Prevention

Dr. Louis Kaplan

ON 17 OCTOBER 1956, the University of Southern California began its first course in aviation safety for key staff aviators, aviation unit commanders, and installation safety directors of the Department of the Army. With the graduation of the sixth class on 20 December 1957, 102 Army officers, ranging in rank from first lieutenant to colonel, and 9 civilian safety directors and investigators had attended this course.

The University of Southern California is the only civilian institution in the nation providing such services. The Aviation Safety Program includes training not only for the Department of the Army, but also for the Navy, Air Force, and civilian aviation groups.

The Army program was established after two civilians and four Army Aviators attended several of the Air Force courses and recommended the development of a similar program for Army Aviators. The Army program differs from others the University conducts in that it not only seeks to produce specialists in flight safety, but also to prepare personnel who will be qualified to advise commanders in aviation safety matters, so that effective aircraft prevention methods may be exercised through command channels.

Dr. Louis Kaplan is director of the Aviation Safety Division, University of Southern California, Los Angeles. Views expressed in this article are the author's and are not necessarily those of the Department of the Army or of the U. S. Army Aviation School.
—The Editor

NATURE OF THE COURSE

This is an 8-week program

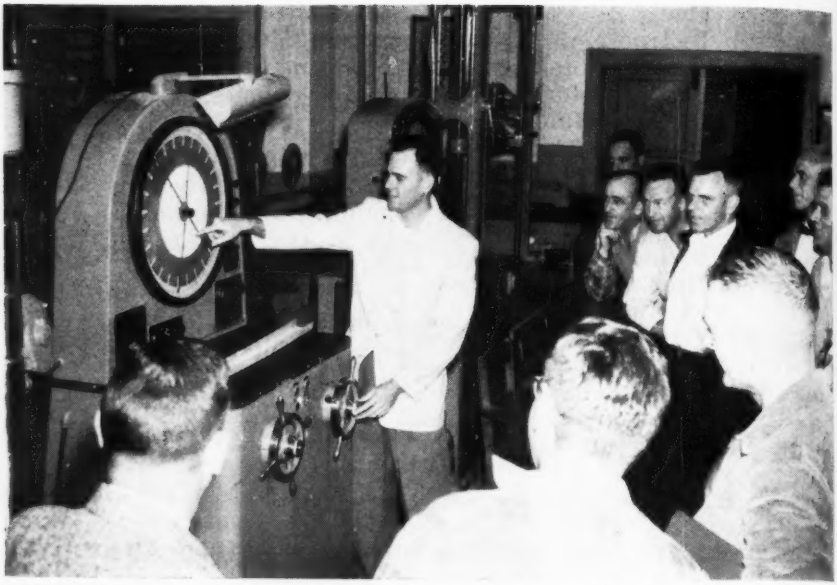
which involves 240 hours of classroom instruction. In addition, 16 hours are devoted to field trips, and 4 hours to indoctrination on the Human Centrifuge. Nonacademic activities include 34 hours set aside for physical conditioning, 28 hours for flying proficiency, and 16 hours for in- and out-processing and graduation. Upon successful completion of the course, students receive 10 units of University credit and a certificate. Enrollment is limited to 15 to 18 students per class. Prerequisites include rating as (1) an Army Aviator, or (2) a Civil Service Army Flight Instructor, or (3) a Safety Director of an Army unit or installation utilizing Army aircraft. In addition, students should have a working knowledge of high school algebra and physics.

The Army Aviation Safety Course deals with five subject areas. These are Aeronautical Engineering, Aviation Physiology, Aircraft Accident Investigation and Reporting, Aviation Psychology, and Aircraft Accident Prevention. A brief description of each subject follows.

AERONAUTICAL ENGINEERING

Approximately 104 classroom hours are devoted to the study of Aeronautical Engineering.

Safety course members inspect Flying Crane helicopter



Tension applied by machine tests strength of metal

The purpose of this course is to acquaint students with the characteristics, capabilities, and limitations of aircraft, and to furnish technical engineering training which emphasizes the critical areas of flying and maintenance operations.

Almost 80 percent of the course content deals with information and concepts which may contribute to the prevention of aircraft accidents. The remainder provides information which will assist in the investigation of aircraft accidents.

Instruction begins with a review of mathematics and physics which will be applied to engineering problems. This is followed by the study of aircraft structures, basic aerodynamic forces, flight loads, ground loads, strength limitations, analysis of airplane performances, stability and control, and, finally, the application of these principles to helicopter engineering.

Throughout this course, application is made to practical aspects of flying. Engineering theory has been reduced to the minimum required for understanding the principles involved.

AVIATION PHYSIOLOGY

Twenty-six hours of instruction are presented here under the direction of a flight surgeon. This course deals with the human element in aircraft accident prevention and investigation. The subjects covered include the physics of the atmosphere in relation to respiration, circulation, and vision, as well as the effects of hypoxia. Human stresses, such as vibration and noise, nutrition, illness, and the effects of drugs, alcohol, and tobacco, are related to accident prevention. Aircraft environ-

ment and body adaptation, acceleration, pilot selection, training and conditioning, fatigue, and the use of the surgeon or physician in aircraft accident prevention and investigation are additional subjects considered in an effort to acquaint students with the basic physiology of flight essential to the understanding of physiological stresses.

ACCIDENT INVESTIGATION

Fifty-four hours are devoted to teaching students how to investigate Army aircraft accidents, and how to prepare the required reports. The emphasis in this course is not on investigation techniques alone, but on the use of investigative procedures for the prevention of aircraft accidents.

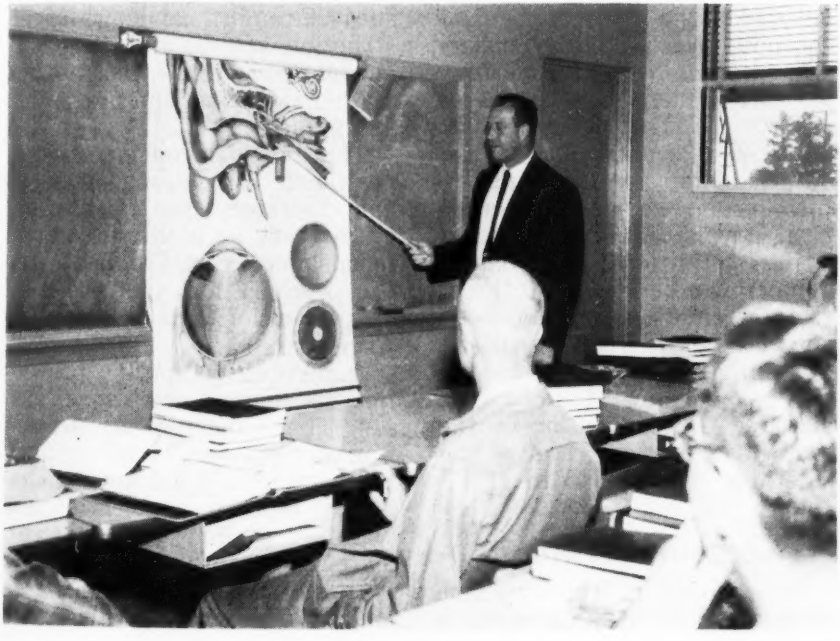
Students are acquainted with the regulations governing accident investigation, the qualities and requirements of an investigator, procedures for determining cause factors in aircraft accidents, how to prepare preaccident plans, the initial procedures to be followed at the scene of an accident, how to gather and interpret evidence, the use to be made of specialists, and how to prepare a report.

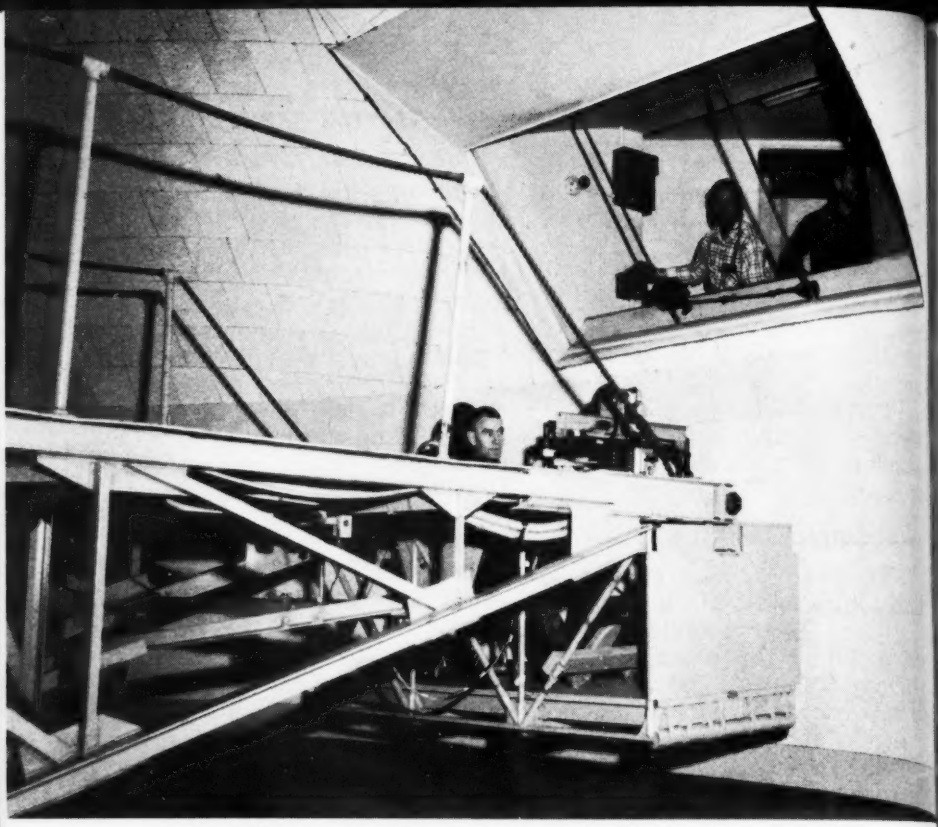
Actual practice in accident investigation is provided by a field problem involving wrecked aircraft furnished by the Army.

AVIATION PSYCHOLOGY

The purpose of this course is to present the psychological factors which are important to aircraft accident prevention and investigation.

Aviation physiology is important part of curriculum





Centrifuge acquaints aviators with effects of acceleration

Thirty classroom hours are devoted to the study of the basic concepts of aviation psychology, the prediction of human behavior, the prediction of accidents, and the concept of proneness accident. Psychological causes of accidents; how learning, remembering, sensation, perception, and attention may affect flying activities; psychomotor behavior and errors; and the effects of emotions are additional subjects considered. The design of equipment for human use and the psychological factors associated with accident prevention and investigation receive considerable emphasis in this course.

ACCIDENT PREVENTION

In addition to the emphasis on aircraft accident prevention, which is a major part of each subject taught, 26 hours of instruction are devoted to an organized consideration of applied aircraft accident prevention techniques.

This includes consideration of pertinent regulations, manuals and directives; the relationship of aircraft accident prevention to mission accomplishment; and the organization and structure of prevention activities in the Army.

A number of specific prevention techniques are also discussed. These include the prevention survey, the safety council, near-accident and operational hazard reporting, education and training, product improvement, materiel deficiency reporting systems, and analysis of hazards and other devices which have

been used successfully in various accident prevention programs.

HUMAN CENTRIFUGE

The Human Centrifuge is used to provide students with the opportunity to experience personally the effects of acceleration forces on the human body. Each student receives four hours of instruction and becomes acquainted with many physiological and psychological responses to acceleration.

Among the phenomena demonstrated are the effects of G on arm and leg movements, upon reaction time, and upon movement time. The illusions of roll, pitch, and tumbling caused by G forces are shown. Effects of head movements, and of long exposure to G, and the use of protective equipment are demonstrated. A closed circuit TV enables all students to observe and experience these phenomena.

CONCLUSION

This entire program is an intensive course of instruction which demands a great deal of energy and effort from students. Experience has shown that personnel attending this course profit greatly from the instruction received. They are better equipped for their careers in aviation and develop a new insight into their potential contribution to aircraft accident prevention and investigation activities.

Graduates of this course have provided a definite impetus to Army aircraft accident prevention. It is expected that as more men are trained in this program they will contribute materially to the reduction of aircraft accidents.

The U. S. Army Board for Aviation Accident Research is in a position to really appreciate the effects of the Army Aviation Safety Course. As graduates of the course have taken their places in the field, the Board has noted a constant improvement in aircraft accident investigation and reporting, and a new and magnified interest in the field of aircraft accident prevention.—The Editor

AOCP Requisitions And Reports

Brigadier General William B. Bunker, TC

INSPECTORS AND STAFF VISITORS, looking at the aircraft supply situation at various Army installations in the United States and at special reports submitted by Army Commanders, have shown a general tendency to regard an aircraft out of commission for lack of a part as a failure in the supply system designed to support the aircraft. There has also been some indication that the definition of the term "Aircraft Out of Commission for Parts" will be further limited in Army Regulations to more accurately reflect the supply situation. Before such action is taken, the Transportation Supply and Maintenance Command believes that the purposes and use of the AOCP requisition and report should be more carefully evaluated.

History of the Term "AOCP." The Air Force term AOCP was adopted by the Army. In the Air Force, the aircraft is a primary weapon of the Commander and the term AOCP reflects current status. Therefore the Commander is vitally interested in knowing at any particular moment the percentage of his combat strength available for operations, that portion which can be made operational by extra effort on his part, and those aircraft which cannot be made available for operations within

General William B. Bunker is Commander of the Transportation Supply and Maintenance Command, St. Louis, Mo. Views expressed in this article are the author's and are not necessarily those of the Department of the Army or of the U. S. Army Aviation School.—The Editor

the capabilities of his command.

The AOCP status of an aircraft indicates that the aircraft is not available for operational commitment and that responsibility for this status is outside the jurisdiction of the Commander. Similarly, the AOCP requisition indicates to the supply organization that an aircraft can be placed in an operational status by supplying the part(s) covered by this particular requisition. Within these criteria, the term AOCP serves a useful purpose. When used to indicate that the condition has arisen because of failure of the supply system, the reporting and requisitioning procedure becomes less valid.

Valid AOCP Reasons. There are various reasons other than a failure in the supply system itself for an aircraft to become AOCP. The most conspicuous of these is an aircraft which suffers major damage due to landing or ground-handling accidents. Obviously, sufficient parts to repair major damage usually are not available at the airfield on which the accident occurs, particularly where only a few aircraft are located at an Army installation. When an aircraft requires a great number of low usage parts for such repair, it normally becomes AOCP until these parts can be secured through the supply system. A lavish stockage of every conceivable part for each type aircraft must be maintained by each airfield to preclude such an AOCP.

Second, many aircraft become AOCP for a particular part which has been changed due to technical difficulties. Therefore, it is necessary to procure and issue a replacement part when usage indicates a particular part is subject to premature failure, or when inadequate quality control by the manufacturer results in insufficient design strength. Obviously, this part does not exist in the supply system until the difficulty has been ascertained, the part has been placed on order, and the proper production lead time has ensued. If, as is frequently the case, this part involves flight safety, aircraft will automatically remain in an AOCP situation until the part has been delivered. Even when the aircraft with the old part is maintained in service, the increased usage or the requirement to replace the old part with a new one will frequently result in an unavoidable AOCP for this new part.

And finally, since the original stockage of spare parts to support any aircraft is generally made from drawings and engineering estimates long before the aircraft itself has been placed in operation, any unforeseen failures in parts which were considered to be immune to wear will result in an AOCP situation for the aircraft until a supply of these parts can be obtained. When, as is customarily the case, the requirement to stock such a part arises quickly on a broad scale to support several identical aircraft, a considerable number of them may become grounded at the same time because the part is not available in the support system.

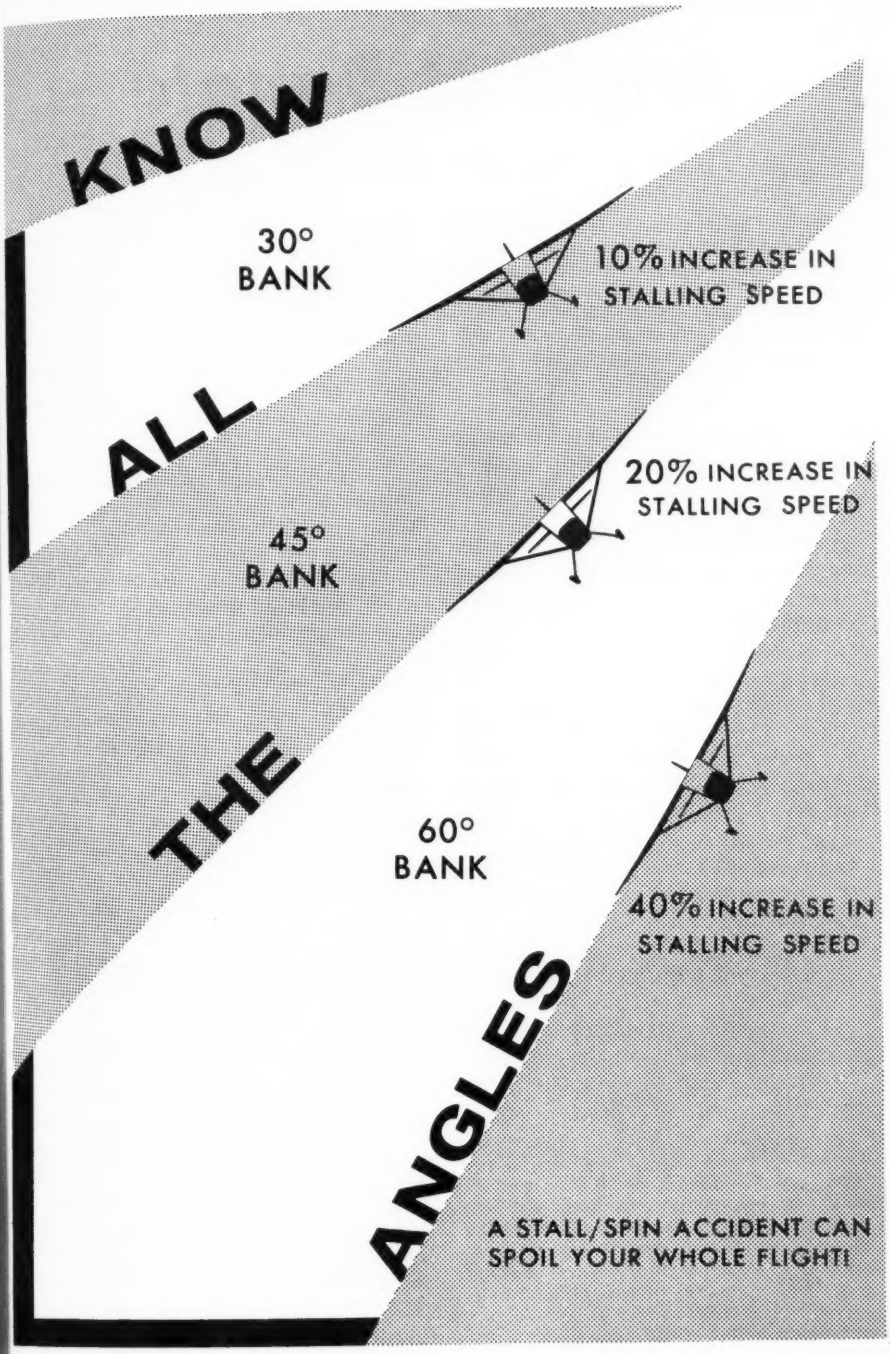
Abuse of the AOCP Requisitioning Procedure. The AOCP requisitioning procedure entails the ills of any priority system

in that at times the customer will tend to use it to cover his own oversight and mistakes. Thus, a maintenance organization which has failed to accurately forecast its requirements for any particular part will resort to the AOCP requisition in an effort to expedite deliveries of parts which should be on hand by normal replenishment requisition procedures. In some instances the maintenance organizations will use the AOCP requisition in an effort to expedite the replenishment of stocks, even though no particular aircraft is out of commission for lack of the parts. Requisitions for such nonfunctional items as ashtrays, cigarette lighters, and wheel chocks have actually been marked AOCP by the requisitioning activity. Such abuses, while not overly common, do interfere with the orderly processing of requisitions and present a false picture when AOCP requisitions or percentages are used as an indication of supply system effectiveness.

Summary of the AOCP-Supply Relationship. Even though some aircraft of all types suffer periodic AOCP condition, this condition does not appear to significantly impede the ability of commanders to perform their missions. The hours of availability of each type of aircraft in the Army system exceed by many times the hours of nonavailability for reasons of AOCP. When it is recognized that the true value of the AOCP requisition is to indicate to the supply organization that such requisition should be processed as rapidly as possible, and to indicate to the commander the availability of his aircraft for operational commitment, it is believed that no change in the AOCP requisitioning and reporting procedures should be considered.

On the other hand, it is not believed proper to consider a low AOCP rate a reflection of an effective supply operation or a high AOCP rate a reflection of a poor one. A zero AOCP rate could be achieved only by complete elimination of accidents, engineering change and unforeseen consumption of parts. Under such circumstances, a zero AOCP rate would indicate a lavish oversupply of parts at every location where aircraft are stationed.

It is, therefore, the recommendation of the U. S. Army Transportation Supply and Maintenance Command, St. Louis, Missouri, that no change be effected in the present procedure for AOCP reporting and requisitioning for Army aircraft. Rather, it is recommended that more emphasis be placed on the value of the AOCP report to field commanders as indications of the effectiveness of their aircraft, and on proper supervision of the use of the AOCP requisition as basically intended. The supply organization can periodically endeavor to eliminate normally expected abuses of such a supply procedure.


KNOW
ALL
THE
ANGLES
30°
BANK
10% INCREASE IN
STALLING SPEED
45°
BANK
20% INCREASE IN
STALLING SPEED
60°
BANK
40% INCREASE IN
STALLING SPEED
A STALL/SPIN ACCIDENT CAN
SPOIL YOUR WHOLE FLIGHT!

These two articles should bring pilots of fixed and rotary wing aircraft up-to-date on this tricky subject--

Angle of Dangle

Major Ollie B. Richie, CE

24 September, Boon Docks, USA: Army Helicopter with three aboard crashes near Swamp City. All aboard escape injury. Pilot states he had a loss of power as he made a turn into the wind to increase rate of climb shortly after take-off.

This could be you, for how many pilots realize that as they execute a turn, especially when operating at near maximum gross weight, additional forces are imposed upon the aircraft and effective weight increases considerably? These added forces are centrifugal force and, of course, gravity.

Let's take a look at our crashed helicopter and develop the situation further. First, this example is a real accident which occurred not too long ago. The circumstances surrounding the accident were not unfavorable to the point that it was inevitable, but the pilot lacked an understanding of the events and of the flight fundamentals involved.

The pilot was participating in a training mission evacuating "wounded." He was operating at near sea level; the temperature was 82°F and the density altitude computed at about 1,600 feet. The load was just under maximum gross and included the two "patients" in the litters, and full gas tanks. (Maximum gross for the H-13E is 2,400 pounds.)

A description of the accident indicates the helicopter took off with a light quartering left crosswind and, after gaining about 60 feet altitude and 30 mph, started a left turn—in the words of the pilot, "to get into the wind to increase my rate of climb." At this time the helicopter began descending and, as the pilot added throttle and collective pitch, continued to descend and crashed going downwind as it completed a 190° turn. The pilot believed he had loss of power.

The following data was developed from the pilot, from witnesses at the scene, from the maintenance people who examined the engine, and from examination of the wreckage: The engine was developing normal power; there was no evidence of material failure or malfunction of any components. The helicopter turned through an arc of about 190°, with the diameter of the turn about 250 feet. The angle of bank was determined to be about 25°. The formula for determining the centrifugal force, angle of bank, G forces,

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and effective weight of the helicopter in the turn are:

A. Centrifugal force = Weight X velocity in feet per second^2 / gravity X radius of turn

$$CF = \frac{WY^2}{gr} = \frac{2{,}387 \times 44^2}{32 \times 125} = 1{,}105$$

B. Tangent of angle of bank = $\frac{CF}{W} = \frac{1{,}105}{2{,}387}$

Tan Θ = .466 angle of bank = 25°

C. g forces = $\frac{1}{\text{cosine of bank angle}}$

$= \frac{1}{.899}$ g = 1.112

D. Effective weight = weight X g
= 2,387 X 1.112
= 2,654 pounds

The maximum gross weight of the H-13E helicopter being 2,400 pounds, it is easy to see that this helicopter was overloaded by 254 pounds while in the turn at an angle of bank of 25°.

It was impossible to maintain altitude without bringing the helicopter back to level attitude.

The effects of 82° temperature, although not contributing directly to this accident, must not be overlooked. The density altitude for this condition at sea level is about 1,600 feet. Furthermore, the engines, if not supercharged, will lose approximately 3 percent power for each 1,000 feet of density altitude.

In analyzing this accident it can only be said that the pilot attempted to fly the helicopter at an impossible attitude for the weight condition of the aircraft. The loss of power alluded to by the pilot can be attributed to the fact that as he went into the turn and the aircraft began to descend, he applied more collective pitch, increasing the angle of attack of the rotor blades. This condition effectively lugged the rpm down and caused loss of lift, not of power.

This article has been written with the hope that it will be read and remembered by pilots operating near maximum gross. Remember, make all turns shallow, a bank of about 10° or less, with a rate of turn of 3° per second. Also remember that rate of climb will not be affected by turning into the wind —only the angle of climb is affected.

Tangle with the Angle

IF YOU KNOW your stall speed increases with bank angle, you're right. If you don't know *how much* it increases, watch out! You may be dead wrong!

Ask another pilot what happens to stall speed in a steeply banked turn. Ask him seriously. You want to know. He'll think you are pretty much of a Dilbert, and his sage reply will be something like, "It goes up, naturally." More than likely, he has imparted in those three words his total knowledge of the subject.

Though all pilots know stall

This article is reprinted from the January, 1957 issue of APPROACH, the Naval Aviation Safety Review. Views expressed in this article are not necessarily those of the Department of the Army or of the U. S. Army Aviation School.—The Editor

speeds are higher in a turn, too few realize *why* or *how much.* Merely knowing it increases seems to satisfy some pilots. But ignorance of the relationship between angle of bank and stall speed is the reason for the large number of stall/spin accidents.

Over half of the pilot-error accidents occur in the landing phase of the flight. A very high percentage of these accidents are of the "stalled, spun into the ground" variety.

So—do *you* know the *why* and *how much?* If not, the few minutes you spend here will mean more than the Rock of Gibraltar when it comes to life insurance.

Why?

First, why is stall speed higher in a banked turn?

Stall occurs when design lifting capability of the wing is exceeded. Angle of attack, speed, drag, weight and angle of bank all contribute toward reaching this design limit. Makes no difference if you're flying a delta wing supersonic stovepipe or a P2V, they're sisters-under-the-skin.

You know that lift varies directly with speed — low speed, low lift. You also know that lift varies with the angle of attack —higher angle of attack, higher lift (up to the stalling angle).

What happens when you bend your iron bird into a steeply banked turn? To hold it, you have to haul back on the stick and your airspeed drops off some. You also get that sit-down-harder feeling in the seat which indicates additional G-loading on the airplane from the centrifugal force generated.

Now we have something to work with that indicates stall speeds are going to be higher in this turn: G-force, which in other words, makes the effective weight of the airplane greater than the actual weight, and hence requires more lift; the pull on the stick which increases the angle of attack; and the drop in airspeed during the turn. They're all tied in together.

As you can see, the lift required in a 30-degree bank is only slightly greater than the weight. In the 60-degree bank, the lift is twice the actual weight, but equal to the effective weight. The steeper the angle of bank, the greater the lift requirement.

To get this extra lift which will overcome the G-effect of centrifugal force, we pull back on the stick and increase the angle of attack of the wing. This increased angle of attack causes a rise in induced drag (which incidentally, is always higher at slower airspeeds). Increasing the drag decreases the airspeed.

See how this package all ties together? *Low airspeeds and steep bank angles are not compatible.* In the turn, you tell the wing it must produce more lift, and it does that—up to a point. Beyond its capability to produce more, it stalls out trying.

There you have the *why* of higher stall speeds in a banked turn. Now let's discuss the *how much.*

How Much?

For the mathematicians, here's the formula:

$$V_2 = V_1\sqrt{\frac{1}{\text{cosine of angle of bank}}}$$

Where:

V_2 is the new stall speed, in turn.

V_1 is the stall speed at 1 G, wings level, given weight.

But since everyone didn't get an A in math, let's put it into words and pictures.

The cosine function runs from 1.0 when the wings are level to 0.866 in a 30° bank and 0.035 in an 88° bank (infinity in a 90° bank).

Peer at that quantity under the square root sign. The bigger the number underneath the line, the smaller the increase in stall speed. Let's solve right here the 30° and the 60° banks, using a hypothetical airplane that stalls at 100 knots, wings level. We'll shoot for ball park answers.

First, 30° bank:

$$V_2 = 100\sqrt{\frac{1}{.866}}$$
$$= 100\sqrt{1.15}$$
$$= 100 \times 1.07$$

V_2 = 107 knots, new stalling speed in 30° bank turn.

Redoing it for the steeper bank where cosine of 60° = .5:

$$V_2 = 100\sqrt{\frac{1}{.5}}$$
$$= 100\sqrt{2}$$
$$= 100 \times 1.41$$

V_2 = 141 knots, new stalling speed in 60° bank turn. Are you convinced?

Know this too, the stall speed is proportionately higher at any bank angle for heavier operating weights, but the percentage increase is the same for any weight at a given bank angle.

A simple thumb rule for angle of bank versus approximate stall speed increase — 30° bank is a 10% increase; 45° bank is 20% increase; 60° bank is 40% increase; 75° bank is 100% increase. (See page 13.)

That "hot" vertical break over the ship or the field will really take a lot of airspeed to keep from spinning out of the break-up. Or when you're overshooting the windline for landing, will you wrap it up tighter or take it around? Just remember that above 60° banks, your stall speed goes clear out of sight in an awful hurry. It is here that the stall/spin accident occurs.

Now what have you learned? What kind of answer can you give the next generation aviator who asks you the question we started out with: "What happens to stall speed in a steeply banked turn?

You know that stall occurs when you exceed the design lifting capability of your wings.

An increase in gross weight raises the basic 1-G stall speed.

G in a turn acts as an effective weight increase.

Stall speed rises rapidly at steep bank angles.

In a 65-degree bank, your stalling speed is half again as high as with wings level (an amazing 150% of basic stall speed).

These rules are applicable to any aircraft and at any weight . . . so, gents —

In a banked turn, it pays to know all the angles!

Army Contract Training Successful at Camp Gary

N. G. Howell

HOW DOES A CONTRACT SCHOOL operate? Who controls the operation? How is the high degree of efficiency realized? Let's take an inside look at the U. S. Army's contract school at Camp Gary, Texas.

Wm. J. Graham & Son, Inc., contractor to the U. S. Army in primary fixed wing pilot training, started student training at Camp Gary, Texas, 7 January 1957. By 4 November 1957, 621 students had graduated and gone to Fort Rucker for the advanced course.

The training at Camp Gary is done on a cost plus fixed fee contract. The contractor pays the bills and is reimbursed by the Army for authorized expenditures. His only source of profit is the fixed fee allowed per student flying hour. Nonauthorized expenditures must be paid from this profit. The Army makes available to the contractor the site and equipment needed for the training and provides a training syllabus. The contractor then employs the personnel to do the job and sets up his administrative and operating procedures, which are subject to certain controls described below.

The Army is free to impose new requirements on the contractor during a contract year, authorizing additional expenditures for which the contractor may be reimbursed.

Mr. N. G. Howell is the director of training at Camp Gary. He was formerly flight advisor to the Director of Instruction, U. S. Army Aviation School, Ft Rucker, Ala. Views expressed in this article are the author's and are not necessarily those of the Department of the Army or of the U. S. Army Aviation School.

—The Editor

TEAMWORK NECESSARY

Contract operation is premised on teamwork, both within the contractor organization and between the contractor personnel, military personnel, and civil

service administrative personnel. The key men in this teamwork plan are: the military commander, the contractor and the administrative contracting officer (employed by Civil Service). Working together, these men can make great strides in a training program. The contractor's procedures are subject to approval by the other two key personnel. When the contractor sees the justified need for an additional training facility, he files a request for the item. Generally, the contracting officer's approval follows if the military commander approves. An alert contractor usually keeps the other key men swamped with requests for items which are needed to improve training.

Three men make up the Civil Service part of this team at Camp Gary: the administrative contracting officer, the property administrator, and the auditor. These men are responsible to Fourth U. S. Army Headquarters. A prime contract awarded to a contractor has two basic parties to the instrument—the United States of America and the contractor. The terms of the contract, in effect, delegate to the assigned contracting officer full authority and responsibility to assume in the name of the United States Government its position as a party to the contract. He has the ability to make cogent decisions and commitments which may be reduced to a binding agreement. His ability lies in his solid business judgment, his sense of equity, and his willing-

Mockups play important role in training

King-size wings decorate chairs reserved for those who solo

ness to do big business with big business.

The property administrator is the representative of the contracting officer for ensuring compliance with the control requirements relative to Government property. He is not under the supervision of the contracting officer; however, they are of mutual and harmonious assistance to each other. The property administrator is responsible for the functional review and appraisal of the contractor's property control system. It is the duty of the assigned auditor to audit expenditures made by the contractor for which reimbursement is being requested under the terms of the contract and to render aid to the contracting officer with respect to the audit aspect of the contractor's operation.

The military commander, 23 other rated officers and 22 enlisted men comprise the military permanent party at Camp Gary. They are charged with the responsibility of the military operation of the post and checking the contractor's job performance. The rated officers conduct at least one-half of the student demonstration (check) flights and all the civilian instructor demonstration flights. This is to ensure high quality, standardized instruction. They also visit student briefings and academic classes as a further check on the contractor's efficiency. One rated officer serves as Army Aircraft Maintenance Officer in a quality control and advisory capacity within the Aircraft Maintenance Department. Dispensary, churches, officers club, PX and post theater are operated by the military as they are on any other post.

The efficiency of the contractor's operation comes primarily from two sources: sound

business practices; employment and retention of professionals to do specialized work. Wm. J. Graham & Son, Inc., employs an assistant general manager, a comptroller, and a director of administration, all highly skilled to aid in directing the company policies and procedures.

FACILITIES EXPANDED

When the contract operation was started at Camp Gary, none of the following services was conveniently located to the other: post office, telegraph station, barber shop, cafeteria, photo shop, laundry, etc. These services have now been combined under one roof at a central location on the post. Of the above services, only the cafeteria and telegraph service are operated by the contractor. Other business services are his responsibility, but are leased to commercial concerns on a nonprofit basis to him. Obviously, the contractor is responsible for academic, link, and flight training of students, but few people outside the contract school realize the vast extent of his total responsibility. Aircraft maintenance, as well as base maintenance, is done by contractor personnel. The fire department and post security guard are the contractor's responsibility, as is supply. Contractor personnel conduct the student physical training program. The contractor employs personnel to operate the following functions: control

Bird Dog cockpit doubles as "classroom" for students

tower, weather, field operation, flying and ground safety, forms and records, refueling, public information, publications, communications, post housing, hobby shop, bowling alley, golf driving range, etc. Professionals are employed to fill all the key positions in the above offices. At Camp Gary an instructor's position is considered a key position. Compared with a military school, the contractor occupies an enviable place in finding highly qualified men to fill these positions. He is not restricted to any one or all of the military services in selecting employees. He advertises a well defined stabilized position at competitive wages in his effort to seek out the best qualified personnel available. He wastes little time in eliminating the employees of questionable value to the mission. The contractor employs a director of personnel who is an expert in his field to help department heads with the screening process.

When you realize that all these professional men and women are working for one company in a united effort toward a common goal, you are beginning to get the spirit of a contract flight training program. There are no departmental fights. Personnel in any one department, knowing that their work is vital to the operation, fully realize that no one department can operate independently. Such teamwork makes red tape all but disappear in normal operation.

Contract pilot training is not of recent origin. In October 1938, Brigadier General H. H. Arnold, then Chief of the Army Air Corps, first discussed the possibility of this type training. On 1 July 1939, nine contract schools were opened to provide the primary phase of military flight training. A peak of 56 schools was reached in 1943. Graham Aviation Company started one of these operations in March 1941 at Americus, Georgia.

The surplus of military pilots following World War II necessitated the closing of all contract schools. A survey conducted in 1948 by the Standard Research Institute of California resulted in invitations for bids on contract operation of two flight training schools. Graham Aviation Company was the successful bidder for operation of the Greenville, Mississippi base. This operation was later moved to Marianna, Florida and has become the Flying Training Air Force (FlyTAF) "showplace" school. Wm. J. Graham & Son, Inc., was again a successful bidder when the Army Primary Fixed Wing Pilot Training Program was placed on a civilian contract basis at Camp Gary, Texas. This contract was signed 18 September 1956, making available to the Army the services of the world's largest civilian aviation school organization.

AN ARMY AVIATOR departs Pittsburgh, Pa., on an IFR flight plan to La Guardia, N. Y., with Hempstead, N. Y., as the alternate. His radio equipment consists of VHF, LF, Omni, and ADF. The ceiling en route is 400 to 600 feet with visibility 2 miles in light rain. Cloud tops are 12,000 feet. Destination weather is reported as 600 feet overcast, visibility 1½ miles with rain. Pittsburgh has 1,700 feet and 3 miles, with clear weather to the west.

His original ATC clearance read: cleared to La Guardia LF range via V-12 Harrisburg, V-162 S Reinholds intersection, V-254 Pottstown, V-251 Patterson Beacon, direct to La Guardia, maintain 8,000 feet.

Ten minutes west of Altoona, ATC contacted the aviator and revised his clearance to read: from present position V-12 to West Chester, V-3 to Patterson Beacon, direct to La Guardia, maintain 8,000 feet. He was again contacted ten minutes west of Harrisburg with another revised clearance. ATC cleared him to La Guardia via the original clearance from his present position on V-12 at Harrisburg. He received this message loud and clear. He tried to acknowledge the clearance but discovered his transmitter to be inoperative. All navigational radios were working perfectly.

Several alternatives are possible. Indicate by a √ the best answer or answers.

☐ **Since VFR weather prevails at Pittsburgh, he should turn perpendicular to the airway, attempt to let down, and return to his point of takeoff.**

☐ **Continue on the last clearance received and acknowledged knowing his transmission is not being received.**

☐ **Turn off the airway and climb—the tops of the clouds may be lower than forecast—then fly west until he can descend VFR.**

☐ **Assume ATC is broadcasting in the blind and adhere to the first revision of the original clearance.**

Reference Chart 16, TM 11-2557.

The correct solution to the PUZZLER may be found on page 33.

Formation Flying With Helicopters

CWO Keith W. Glasgow, TC

WHEN SPEAKING OF FORMATION FLYING, one almost automatically thinks of the Blue Devils, Hell's Angels, or the Thunder Jets. It's not necessarily so; helicopters fly formation, too.

Formation flying in helicopters is necessary when equipment, personnel, or both are needed in an area at approximately the same time; at times when many helicopters are flying to one destination; when marginal weather is expected; or when flying in air shows and demonstrations.

One of the best known groups to fly in air shows is the Precision Flight Team, better known as the Square Dance Team. This group provides a spectacle with their precise air work that usually brings down the house at air shows.

Composed of working instructors (all warrant officers), the team members rehearse during off-duty hours. The main qualification for becoming a team member is skill in formation flying.

One team member said, "You have to be able to fly by feel and sound. You have to know the operating limits, and good timing is of utmost importance."

Confidence in fellow members of the team comes high on the list of things important to success in these spectacular maneuvers, and all agree that team spirit is a must.

While the Precision Flight Team does not engage in formation flying as such, they are quick to point out similarities. Some of these are coordination,

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—The Editor

good timing, alertness, and teamwork.

ADVANTAGES CITED

Advantages gained in formation flying are deployment of troops and equipment in large numbers and quantities at one time to a given area; maintaining positive control of a large number of aircraft on a single mission; improving coordination of the pilot, and enabling him to feel at ease when in close proximity to other helicopters in flight or on the ground.

The positions in a three-plane V-formation are numbered as in a fixed wing formation, the leader being number 1, the helicopter on the leader's right number 2, the one on his left number 3. Helicopters 2 and 3 fly to the side and back at an angle of 30° in a stepped-up position. An angle of 30° is used in preference to the 45° angle often used in fixed wing aircraft because the leader is able to keep his wingmen in better view, especially in larger type helicopters when rearward vision is somewhat limited.

LEADER RESPONSIBLE

The leader of the formation is responsible for the safety, navigation, and type of formation (whether in echelon, V, trail, loose, or close) until he turns the flight over to someone else. Prior to all flights a briefing should be given to include radio frequencies, planned route, weather information, en route navigational aids, hand signals to be used, and any other pertinent information. All members of a flight must be so well briefed that, should the occasion arise, any one of them could leave the flight and continue on alone or return to takeoff point.

The leader will indicate either a takeoff in formation or a join-up after takeoff. In the case of a formation takeoff, the leader will see that each member is ready and in approximate V-formation positions on the runway or in the takeoff area. The leader makes a normal takeoff, airspeed slightly over altitude, especially in the initial portion of the takeoff to give his wingmen a chance to get into their proper stepped-up positions. The wingmen should get into position and above the lead helicopter as quickly as possible in order to avoid downwash, and not get so far behind that it will take excessive power to catch and join up on the lead aircraft.

In the event a join-up after takeoff is desired, the following procedure can be used. Leader makes a normal takeoff and is followed at regular intervals by number 2 and number 3. When leader reaches desired altitude, he starts a gentle turn (approximately 5°) to the left, unless terrain, traffic patterns, or unsafe conditions prevent a left turn; in such case, a right turn can be made by leader.

As soon as leader starts his left turn, number 2 starts a left turn, keeping the nose of his aircraft headed approximately twenty degrees ahead of leader until he joins up in formation in the number 3 spot. Immediately after joining up a crossover is made by skidding across slightly behind and above leader to the number 2 position. Number 3 aircraft starts his turn inside the leader's at the same time number 2 started his turn, but

since he took off after 1 and 2 he is far enough behind that the number 2 man will have time to get into position before number 3 catches the formation and joins it.

POWER SETTINGS

Normal power settings are used by all three aircraft until join-up is accomplished. Attention must be paid to rate of closing as aircraft nears leader, so as not to overshoot the proper position yet not closing so slowly that the join-up is unnecessarily delayed. Care has to be taken by wingmen to avoid getting their aircraft in a position that will cause them to lose sight of the lead aircraft.

Once number 3 is joined, he lines up with number 2 for his proper distance back. Number 2 and 3 should fly stepped-up above the lead aircraft so that their rotor blades are approximately four feet above the leader's rotor blades.

Oftentimes radio is used by leader to give the direction in which he plans to turn, but this is unnecessary if the leader will start his turn slowly and increase his bank gradually to the degree of bank desired. With little practice, wingmen should be able to follow such maneuvers without prior warning. This skill assists the pilot when radios become inoperative or when radio silence is necessary.

In a bank the wingmen keep their same relative positions, stepped-up as if they were flying straight and level. In order to maintain their positions without abrupt changes to controls, the wingmen have to anticipate the maneuver and make power changes immediately. In a left turn the number 3 man needs to reduce collective pitch slightly and, depending on the degree of bank, perhaps apply a bit of aft pressure on the cyclic. When rolling out of a turn, additional power is needed and at times slight forward pressure on cyclic is necessary to maintain the same position. The number 2 man makes the same corrections in a left turn only in reverse order, first applying then reducing power to accomplish roll out.

SEEK BEST ROUTE

In straight and level flight the flight leader's attention is mainly ahead in order to lead the flight safely over the best route. Help in scanning the skies may be given by wingmen. The number 3 man scans from straight ahead, then right to almost 180° rear. Number 2 man scans from straight ahead and left to 180° or as near 180° as practical. In this manner, wingmen are able to keep a sharp lookout for other aircraft, enemy positions, or along the route they are flying and still never lose sight of the lead aircraft.

When arriving at a destination, the formations can either land in formation or individually. In making formation landings, it is better to make landing approaches to the ground when possible, to prevent rotorwash from disturbing the landings of wingmen or stirring up unnecessary dirt.

In most cases, under normal flying conditions the flight leader will choose to have the planes in the flight land individually. Prior to reaching point of landing the flight leader puts the

flight in a right or left echelon: A right echelon if the pattern is to be left and left echelon if a righthand pattern is used. First the leader breaks the formation after passing the lead to the second plane in the echelon, and the second man passes the lead to the third man and follows the leader in for a landing. Number 3 man continues on in a straight line until time has elapsed to allow him to break formation at the same time interval as the first two planes. Intervals of a break can be varied to suit the landing facilities available.

Formations can be varied to suit the occasion, and with practice helicopter pilots can feel just as much at home flying formation as flying alone.

NEW DIGEST DISTRIBUTION

The official distribution list of the U. S. ARMY AVIATION DIGEST has been evaluated and revised to provide aviation units in the field with maximum distribution of the 6,000 copies printed monthly. The Adjutant General is responsible for distribution of the DIGEST to all active Army agencies through local publications officers. All aviation staff officers and aviation unit commanders are urged to offer their assistance to unit publications officers to ensure equitable distribution of the DIGEST to aviation personnel.

The new distribution list which is effective with this issue is as follows:

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ROR SPELLS SOAR

CWO Vincent Serio, TC

WITH ROCKETS ON ROTORS, the Army could really roar through the air. If equipped with an auxiliary power boost, the helicopter would be even more versatile in its role.

Nicknamed "ROR," for rocket on rotor, the new device has been tested on the U. S. Marine Corps Sikorsky HRS-2 Chickasaw. The ROR principle can be adapted to many existing helicopters with relatively minor alterations and results in greatly increased performance. The system adds a whopping 20 percent to a rotorcraft's effective power.

For vertical lift and load carrying capabilities at high altitudes, helicopters require a greater amount of power than for normal cruising conditions. An auxiliary power boost system, such as ROR, could provide this necessary extra power for a relatively short duration of time during vertical takeoff before transition to forward flight. Design, development and tests have been completed and military evaluation in the field has proven successful.

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FIRST TEST

The first rocket on rotor test was flown by Sikorsky on 9 March 1954. The United States Marine Corps demonstrated ROR publicly 16 September 1954 at Anacostia Naval Air Station, Washington, D. C. Pilots who had made "front-line evacs" and troop and cargo transport in Korea felt that this device satisfied requirements to ensure "just a mite more power" for better performance under critical conditions.

The four major objectives

this power boost would provide are: Approximately 20 percent boost in power at sea level; ability to take off with nearly 100 percent more payload from sea level to 5,000-foot elevations; increased hovering ceiling under all loads or altitude conditions; and gliding range extended by a factor of 3 to 4 with the primary powerplant inoperative.

In terms of troop load takeoff at sea level, the additional power could be translated into increased capacity of four more combat-equipped troops. Helicopters without ROR usually could carry only half of a normal troop load from sea level to altitudes of 5,000 feet. An example of comparative climb tests is equal to the performance of two helicopters loaded internally to standard gross weight, although the aircraft equipped with ROR has an additional load of 800 pounds in its external cargo sling.

EXTENDED GLIDE

Most of all, the interesting feature guaranteed to please 'copter pilots everywhere is the extended glide range factor of 3 to 4. The gliding radius with the use of ROR is tripled, and the area in which a pilot may choose a suitable landing place is increased NINE TIMES. In this period of austerity, think of the many landing gears and rotor systems, not to mention lives, limbs, and property damage, which may be spared if "just a mite more power" were available for better performance under critical conditions.

The ROR system is simple and lightweight. The motor itself weighs less than 1 pound and measures only 5 inches long. On the Chickasaw a typical system consists of three blade-tip-mounted rocket engines, producing a total of approximately 120 hp; a hub-mounted propellant tank, providing as much as 6 minutes of operation; and a set of simple valves, lines, and controls. The whole ROR system weighs only 67 pounds dry.

The rocket engine operates by the rapid catalytic decomposition of 90 percent hydrogen peroxide and transformation into high temperature steam. While this engine weighs only about 1 pound, it provides 40 pounds of thrust or about 40 hp at normal operating rpm. Fuel for this engine is fed by the pumping action of the rotor. The hub-mounted propellant tank, shaped as a modified aerodynamically clean hemisphere, carries up to 300 pounds of fuel or enough for 6 minutes of operation at full power.

SIMPLE CONTROLS

There are two simple control elements, a master arming switch and an on-off firing switch which actuates all three rocket engines at once. Engines are precalibrated to automatically provide balanced thrust at each blade.

Fuel handling is relatively simple. Service trucks have been designed and constructed for hydrogen peroxide servicing. The trucks are self-contained units capable of transporting approximately 80 gallons of 90 percent unstabilized hydrogen peroxide propellant and an equivalent quantity of water.

A military unit of company size with 15 helicopters has

been observed to operate with few out-of-the-ordinary routine procedures for care and maintenance, storage and servicing of the propellant and systems. Hydrogen peroxide in itself isn't combustible, but when in contact with common materials such as metal, leather, cloth, or wood, such reaction temperatures rise to promote combustion in the material. The degree of reaction varies with the type of material. Glass and silicon products and certain synthetics are affected the least.

FEW COCKPIT CHANGES

Pilots find no great change in the cockpit. A timing clock mounted on the instrument panel indicates in minutes the amount of fuel used and the amount remaining. Operational timers are usually adjusted for 5 minutes usable fuel with 1 minute held in reserve.

The control switches are located on the collective pitch in much the same manner as the servo and landing light switches on the Choctaw. Operation of the switches is electrical to valves at the outlets of the tank to the blade lines. The response is instantaneous. During operation, only a slight hissing noise is apparent while a slight increase of rotor rpm necessitates some reduction of throttle.

It is attested that use of the ROR system gives a warm experience of luxury. The exhilaration of those extra horses pulling a tired tail-end charlie of a large tactical formation, up and out of turbulence, over obstacles, and during downwind high-density conditions is something to ROR about.

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Memo from Flight Surgeon

LIQUID OXYGEN IS NOW BEING adopted by the U. S. Air Force and U. S. Naval aviation. Because both weight and space are critical items in present-day jet aircraft, the bulky gaseous system is slated for gradual discard.

We in the Army have the most urgent weight and space problem in all aviation. Our need for oxygen to combat hypoxia is very real, if generally unrecognized, and it will become increasingly urgent in the future. The solution adopted by our sister services could very well be our own.

In the past we've used very little oxygen equipment. As a result hypoxia and its dangers are virtually unknown to many aviators. This is not surprising. Our aim has always been to use the simplest equipment possible to do the job. When anyone wished to sum up the essence of organic Army Aviation, he characterized it "low and slow." But the future promises many revisions, and even the past shows exceptions. During the war in Korea, aviators sometimes had to fly at 12,000 and 13,000 feet over mountains. As one veteran tells it, "You had to; they had guns on those mountains."

There was also the question of funds for extra equipment. We were new. We had to prove our worth, even to the rest of the Army. We had to become

known and recognized. Recently, an old-time aviator remarked that he was up on the line in Korea several weeks before the personnel of other Army units knew that he was in the Army. Most of them assumed he was Air Force on TDY until he unbuttoned his flying jacket. Until our potential was recognized, we had funds for only the bare necessities.

Furthermore, we ourselves were not indoctrinated. Another Korean veteran tells me that the first time he heard of oxygen equipment occurred when Navy aviators came over at the end of the war to fly patrol on the demarcation line. The Navy used to call a momentary halt around 8,000 or 9,000 feet to ready their equipment. Many of our fellows assume an air of amused tolerance. They had been flying routinely in combat for a couple of years without this extra equipment.

"We used to stagger along the strip, loaded down with useless radio equipment, barely able to get off as it was," said one Korean veteran. "A couple more pounds of equipment would have killed me, not helped me. Anyway," he went on, "why bother? The number of times we fly high we can count on our fingertips."

All of which may be true. Yet, the need is a real one.

For example, in night vision the retina of the eye is the most sensitive external element of the body to changes in the oxygen content of the blood. As a result, you lose 25 percent night vision at 8,000 feet altitude. Should you chain-smoke three cigarettes before takeoff—not uncommon with certain pilots—you lose another 25 percent through carbon monoxide inhalation. Add to this the fact that most single-engine aircraft contain a trace of carbon monoxide in the cabin. This potential hazard is even greater during winter operations because of "buttoning up" of the aircraft. The use of oxygen during night flights rapidly overcomes the night vision defect, and protects you from insidious poisoning produced by the aircraft powerplant.

HYPOXIA DANGEROUS

Besides loss of night vision, even moderate hypoxia has some very insidious effects. Often the aviator is unaware that he is experiencing them. Your thought and memory become clouded and you make errors in judgment that would not occur under normal conditions. Severe hypoxia leads to complete collapse and even death within a very few minutes. The aviator who mentioned that he first heard of hypoxia when the Navy aviators came over was telling a sad truth. During the Korean war (and even up to now) this information had been little publicized because of the severe shortage of personnel and facilities. It is true that we seldom fly now at the higher altitudes, but with all-weather flight soon to be universal in Army Aviation, our needs are changing. And even if the average Army Aviator flies very little at a

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The views expressed in this department are not necessarily those of the Department of the Army or of the U. S. Army Aviation School.

—The Editor

higher altitude, there is a real danger when he does.

The Air Force aviator is likely to fly at high altitude on nearly every day of flight. He has been well indoctrinated in the use of oxygen. It is repeated daily, and he knows the penalty if he forgets. As a result, he reaches for his oxygen mask as easily and as spontaneously as we might reach for the throttle. He is never in any danger from hypoxia because he constantly creates his own correct physical environment. We are in a different category, however. Let us say we fly at high altitude just once in two years. We go up either unaware or hazy about the danger involved. In one day, we are more in danger of death or injury than the Air Force pilot in two full years of flight.

EXPERIENCE VALUABLE

It might be mentioned right here that no matter how much we talk of this problem, words cannot take the place of an actual experience in the altitude chamber. Our friends of the Air Force are only too happy to give us this indoctrination free. So why not take advantage of it next time you are near a base that has the equipment? You will never forget the experience—and the lesson learned.

While it is true that we have a critical weight and space problem, the need for oxygen in Army Aviation is becoming increasingly important. The lightweight liquid oxygen system takes up only one-eighth the space of the now obsolescent gaseous system and weighs less than a third as much. It has been tested and improved for aircraft for more than ten years, and the other services are rapidly converting to it. It could very definitely serve our own needs, with little weight and space penalty, and its adoption would solve a vexing problem.

Solution to PUZZLER

On the basis of the factual information contained in the PUZZLER on page 23, the recommended solution is as follows:

Continue on the last clearance received and acknowledged knowing his transmission is not being received.

Ground Resonance

CWO Randolph J. Ewan, TC

THE DICTIONARY DEFINES "resonance" as "the energetic vibration of a body produced by application of a periodic force of nearly the same frequency as that of the free vibration of the affected body." Also, "the condition of two bodies adjusted to have the same frequency of vibration."

From this definition we find that the term "Ground Resonance" can be defined as a vibration of large amplitude resulting from a forced or induced vibration to a mass in contact with, or while resting upon, the ground or some other solid mass. Now, if we consider the helicopter as the mass, we find that the forced vibration usually originates from disturbances in the rotor head. These disturbances are transmitted through the fuselage of the aircraft into the landing gear, which is the reaction member with the ground. In some cases the required amount of forced vibration can be induced by the landing gear rolling over rough terrain or dropping into holes.

The first known case of ground resonance occurred on the Kellett XR-2 Autogiro in 1940. My first contact with ground resonance occurred in a Piasecki HRP-2 helicopter in 1951 and, due to lack of understanding, was quite frightening.

"Frequency," "natural frequency," and "amplitude" are terms which must be thoroughly understood in a discussion of ground resonance. *Frequency* is the number of vibrations or cycles in a given unit of time. *Natural frequency* is the frequency at which a mass or body will

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—The Editor

vibrate with the least input of energy. *Amplitude* is the extent of a vibratory movement, as of a pendulum, measured from the mean position to an extreme, or from one extreme to the other. Amplitude represents the magnitude of the motion or the distance the body moves, whereas the frequency measures the time cycle of such a movement.

FACTORS ENCOUNTERED

What are some of the factors that affect natural frequency and amplitude? Center of gravity location in the vertical plane has a definite effect upon the lateral rolling frequency of a helicopter. Thus, a low c.g. results in a higher frequency and a high c.g. results in a lower frequency. Gross weight associated with the c.g. location also has a bearing on a helicopter's natural frequency. Thus low gross weight increases frequency and high gross weight decreases frequency. Variations of tire pressures, shock strut pressures, and strut metering devices affect the natural frequency of a helicopter resting on its landing gear. Thus, a rigid landing gear with solid wheels and tires would give a low-amplitude, high-frequency type natural frequency characteristic, while shock struts and pneumatic tires would tend to make the natural frequency of a larger amplitude with a lower frequency.

Forced vibrations can and usually do result from disturbances in the rotor head of a helicopter. How? Vibration from the rotor to the fuselage can be caused by blade pattern unbalance. An example of this would be a balanced two-bladed propeller versus a single-bladed propeller without a counterweight. In a helicopter, this pattern unbalance is usually caused by a disturbance in the angular spacing of the rotor blades.

Vibrations can also be caused by blade weight unbalance. It is understandable that blades of unequal weights will have a vibration. The frequency of this vibration will change with rotor rpm, being most apparent at high rotor rpm. Blade weight moment unbalance can exist in blades of equal weight. Variation in blade center of gravity location in respect to the center of rotation can be considered as another source of vibration.

SPACE PATTERN

Control unbalance is another source of vibration. Any rotating body tends to rotate in a given space pattern. If this pattern is disturbed by an external force, unbalanced forces will be transmitted to its mounting structure. If applied to a helicopter, we find that we have a rotor which tends to rotate in a space pattern which can be disturbed by an external force (air), an internal disturbance of the controls by the pilot, or a disturbance that could be set up in an auxiliary boost control unit. When this space pattern is disturbed, unbalanced forces are transmitted by the rotor to the helicopter and could be of such amplitude and frequency that a resonance response could be obtained in the entire helicopter if it is supported or partially supported by its landing gear on the ground.

Blades that are out of track will also give an unbalanced

condition, but this condition usually results in nothing more than a rough flying helicopter with a beat. However, if a blade is far enough out of track, it is possible that enough of an unbalanced condition could be set up to induce ground resonance.

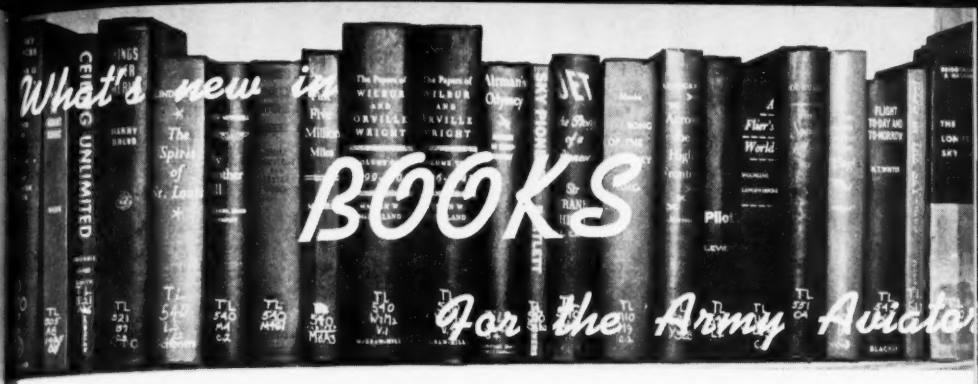
What should we do to avoid ground resonance? Maintenance-wise we can make sure that blade dampers are functioning properly, since malfunctioning dampers could cause a large angular unbalance in the rotor system. Fluid level and static setting of shock struts should be watched carefully. Tire pressure must be maintained in accordance with applicable erection and maintenance manuals. Rotor blades should be tracked when an unbalanced condition exists.

AVOID RESONANCE

As pilots we can avoid resonance by following a few simple rules. High speed taxiing maneuvers combined with rapid directional control applications or rapid application of brakes are conducive to ground resonance. Refrain from making light touch-on landings which may result in wheel padding. Avoid partially airborne conditions for prolonged periods of time as this can result in wheel padding (wheel bounce or buffeting). When landing on rough terrain, watch for indications of ground resonance build-up especially in marshy or soft ground. In the event you believe ground resonance is starting, immediately take off to a hover, or if this is impossible, immediately decrease collective pitch and rotor rpm simultaneously.

Since those days of the HRP Piasecki helicopter, I have never had a helicopter go into true ground resonance. I have experienced the initial stages, but these have not progressed into the real thing. I can say that when you have actually gone into true ground resonance, you will never forget it; and if you don't take immediate corrective action, the aircraft will surely destroy itself within a matter of seconds.

There is one thing in our favor, however, and that is the fact that no one has ever gone into ground resonance unless in contact with the ground. And, when a helicopter flies apart, the ground is the best place to be.



NIGHT FIGHTER—C. F. Rawnsley and Robert Wright (Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y. $4.50)

Reviewed by
Captain Theodore Ferry
U. S. Army Board for Aviation Accident Research

Night fighter aircraft, using radar to locate and shoot down the enemy at night, were flown by only a few of the many unknown heroes of World War II. This book tells their story.

Basically a story of British night fighter aircraft, it begins about the time Hitler entered the low countries. Although the English probably led all others in radar development at this time, no airborne use was made of this equipment in detecting enemy aircraft at night. The first night fighters depended on ground vectors and their own good eyes aloft.

When the radar operator peered into the scope of the first black box installed in an aircraft, much was expected; actually very little happened. It took long hours of experimenting and many disappointments before the black boxes proved their worth. As radar improved and operator skill increased, German aircraft began to respect and fear the sudden death that struck in the dark.

This book covers the personal experiences of John Cunningham, a pilot, and his radar operator, C. F. Rawnsley. Being the "outstanding night fighter crew of the war," their victories became routine. By the middle of the book, their skill as a team of killers was established, and airborne detection radar had reached a high state of development. From that point on, the book becomes a story of sitting ducks in a shooting gallery. Anyone interested in night fighters or the development of radar will find the book thoroughly enjoyable.

Book reviews appearing in this department do not necessarily reflect the opinions of the Department of the Army or of the U. S. Army Aviation School.—The Editor

THE RUSSIAN STRUGGLE FOR POWER, 1914-1917, A Study of Russian Foreign Policy During the First World War—C. J. Smith (Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. $4.75)

Reviewed by
L. D. Parrish, Ph.D.
Educational Advisor, MOI, U. S. Army Aviation School

An aspect of the death agony of decayed Romanov government of Russia is vividly pictured in this volume by Professor C. Jay Smith, University of Georgia.

Shortly after the Bolshevik coup d'etat of 1917, Soviet People's Commissar of Foreign Affairs, Lyov Bronstein-Trotsky, published the secret treaties of the Tzars which caused grave embarrassment in most foreign offices in Europe.

One result was the partial opening of other national archives for schol-

arly research. Another result was an opportunity for a new analysis of the official Russian mind. Dr. Smith reveals a tortuous diplomatic record, probably quite as complex as the foreign policy of the contemporary Soviet Union.

A student of military science will find this discussion of the 1914 Russian struggle for power strangely up to date. Titles, forms, and men have changed, but the fundamental Russian policy has some of the same goals it had in 1914.

THE HELICOPTER BOOK—Henry B. Lent. (The MacMillan Co., 60 Fifth Ave., New York 11, N. Y. $2.75)

Reviewed by
Frank E. Randle, Librarian
U. S. Army Aviation School

This book tells the story of the S-55 helicopter: how it was designed, manufactured, tested, and flown. It was produced with the help of the Sikorsky Helicopter Division of United Aircraft Corporation. Pictures and text combine to gave an easy series of lessons as to why helicopters fly, how they are produced, and what they can do when they go to work.

"According to all recognized aerodynamic tests, the bumblebee cannot fly, because of the shape and weight of its body in relation to its total wing area. But the bumblebee does not know this. So it just goes ahead and flies anyway." This was the sign Mr. Igor Sikorsky put on the wall of his office in 1930 in answer to those who said helicopters couldn't do the things he said they could. A visit to Mr. Sikorsky's factory in the pages of this book shows how and why helicopters can do these things.

In the early chapters, we meet the S-55 and tour the plant. Then we see how the S-55 was designed and how the models were tested in the wind tunnel. The most interesting part of the book tells about the test pilots and what they do with the first models which are completed in the factory. The Flight Research Laboratory is called the "torture chamber," since the helicopter is put through all kinds of tests for stress and strain. Other chapters tell about the rotor blades and the precision parts which go to make up an S-55. Finally we take a ride in a completely tested S-55, and then meet the S-56 after we return.

Helicopters and what they do in rescue, patrol, cowboy, and flying-police work are the subject of the rest of this book. It is intended primarily for ages 10-14, but anybody, young or old, could probably learn much more about helicopters from this book.

WEATHER ANALYSIS AND FORECASTING, Vol. II—Sverre Petterssen. (McGraw-Hill Book Company Inc., 330 W. 42nd St., New York 36, N. Y. $8.50)

This is the second of two volumes which constitute a general and complete text on forecasting. Volume II deals with what is commonly called weather. The book begins with a treatment of the exchange processes and develops the theory of air masses and thermodynamic processes. Then condensation and precipitation, convective clouds, showers, thunderstorms, squall lines, and tornadoes are discussed.

A separate chapter is devoted to fog and stratus; subsequent chapters deal with migratory cloud and weather systems. The last three chapters are concerned with the various dynamic and statistical techniques for predicting clouds and weather. Full use is made of recent progress in the field and the latest tools of the trade, such as computing machines.

How to Survive A Forced Landing

Jack Gaty

THE RELIABILITY OF AIRCRAFT engines really is phenomenal. Many pilots fly single-engine airplanes over water and over extremely dangerous terrain without giving a second thought to the problem of a forced landing.

However, even four-engine aircraft have lost sufficient power to require their pilots to make an immediate landing. The reasons for these rather infrequent power failures are legion. There are many possible causes—including water in the fuel, bad maintenance, broken fuel lines, and dozens of other things—which can cause a sudden interruption of power, even in multiengine aircraft.

Mr. Jack Gaty is general manager for Beech Aircraft Corporation. This article first appeared in SAFETY SUGGESTIONS published by that company under the title "Forced Landings." Views expressed in this article are the author's and are not necessarily those of the Department of the Army or of the U. S. Army Aviation School.—The Editor

There are a few pilots who have thought out a proper way to make a forced landing in the event that one does suddenly confront them. These pilots realize that the airplane in which they are flying is highly charged with kinetic energy of motion and that this energy of motion must be gradually absorbed in some way if they are not to suffer serious injuries themselves. In all accidents, the damage to the vehicle and the damage to the people in it are created by the sudden stoppage of the motion. If even a limited amount of distance is used to absorb the energy of motion, the chances are good that the people in the vehicle will not be hurt.

SACRIFICE AIRCRAFT

The pilot must firmly establish in his mind the fact that it is a reasonable thing to sacrifice the airplane in order to save the people, whether or not the airplane is insured. If you live long enough, you can buy

another airplane. Even the insurance companies agree that they prefer to have the airplane sacrificed in an emergency during a forced landing than to have the people killed or injured. The insurance companies prefer to pay for the airplane rather than the people, for the simple reason that *people are more expensive.*

In forced landings, there are various ways to absorb energy. One is to put the airplane down with the wheels retracted on any body of water, even a small one. The water does not even have to be deep in order to function in this manner. The airplane cannot sink into the water more than a few inches before it slows down to the speed of a walk, and it will slide on top of the water for only a couple of hundred feet before slowing down to a walking speed. Another way is to put the airplane into bushes or little trees, such as saplings or small pine trees. In this case again, the wheels would be kept retracted. The small trees usually will bend over and act as a cushioning means for the airplane.

Another way is to select two trees 20 to 30 feet apart and *get the airplane on the ground* before it reaches the two trees, and then let the two trees contact the wings to absorb the energy of the fuselage. Another way is to use one tree for the same purpose, and get the airplane on the ground before allowing the tip of one wing to contact the tree for the purpose of converting part of the energy of forward motion into energy of rotational motion. In other words, slow the airplane down by making it spin on its own center of gravity. This last method is subject to some hazard because of possible injuries and bruises to the occupants due to sudden change of direction of the airplane. It has worked when nothing else was available.

The major idea is to allow the energy of forward motion to be used up at a reasonably slow rate during a few seconds. If it is all dissipated in a fraction of a second, it is certain that all of the occupants will die.

A letter from the owner of a single-engine airplane has written us the details of the method by which he faced a forced landing in mountainous forested country, and was able to walk away from it. His own description of the forced landing follows:

"I left Altoona en route to Parkersburg, flying around Altoona territory for some 20 to 25 minutes and then proceeded on course, running the first 30 minutes out of the left gas tank and then switched to the right tank and ran to Parkersburg; near to Parkersburg airport, I switched back to the left tank and the motor ran for a full five minutes afterwards, which put me some 15 miles below Parkersburg airport."

(The fuel supply to the engine suddenly became interrupted and the engine stopped and could not be restarted, despite all possible efforts of the pilot.)

USE OF TREES

"Then I started down in a glide holding 95 to 100 miles per hour so as to make sure that I would not stall out above the

wooded terrain. I, of course, was working with the switching of tanks, wobble pump and everything I could think of in an attempt to start the motor but all efforts were in vain.

"When I saw that I was coming near the tree tops and that it was going to be impossible to get the motor to run, I shut off all switches and prepared for the slowest landing possible, keeping in mind to have it on the tree tops when it quit flying. I picked a place where the wooded area was light for just a spot approximately 150 yards square, which was on the side of the hill where there were two trees that I felt I could get the nose between, catching the wings and breaking some of the impact. This is exactly what I did; however, when I got to within a couple hundred feet of the trees, I saw I was going to overshoot, still maintaining 95 miles per hour, so I threw the plane into a skidding position and skidded down, leveling off at a point that I knew I could get the nose between the trees.

FUEL LINE BREAKS

"I leveled off and had it completely stalled out when I mushed it in, and it sat down in the underbrush exactly as intended, catching tips of the wings on each tree, uprooting one of the smaller trees and breaking the wing back on the left side, leaving it just slip by the tree and we sat down with little impact. The plane was on a side hill with the left wing higher, which had the fuel, and it appears that the breaking of the fuel line allowed the gas to run down over the exhaust, igniting same. There would not have been too much damage to the airplane had the fire not broken out.

"As requested in your letter, I wish to advise that both Mr. L..... and myself were wearing the safety belts at the time of the accident.

"I would recommend to anyone to whom such an accident would happen to make sure the plane is kept flying until they get it down low enough and then all that is necessary is to go through the same procedure as a normal landing."

It is essential that the occupants be securely fastened to their respective seats to minimize the danger of striking parts of the airplane within the cabin on ground contact. Maximum protection will be afforded by the use of shoulder harness. Tight shoulder harness will prevent "jack knifing" of the body on sudden impact and will restrain the upper torso from most sideward movement. Where shoulder harness is not available, the safety belt should be tightened as tight as possible, to insure retention of the occupant in the seat.

To lessen the danger of fire, the airplane electrical system and engine switches should be turned off prior to contact with trees, water, or ground.

The essential idea to retain, is to be certain that the airplane does not stop suddenly by crashing out of a stall or by running head-on into an obstruction.

Senior Army Aviator of the Month

Lt Colonel John W. Oswalt is Deputy Director of the Combat Developments Office, U. S. Army Aviation School. He attended Liaison Pilot Class Number Two at Fort Sill, Okla., in 1942. He served in World War II with the 1st U. S. Armored Division in North Africa and Italy, later moving to the 15th Army Group where he was the Army Aviation Officer and personal pilot for General Mark W. Clark.

Subsequent assignments included Army Aviation Officer, United States Forces, Austria; Aviation Officer, 6th Army; Department of the Army Liaison Officer, Wright-Patterson AFB; Chief of Aviation Division, Research and Development Office, OCAFF, Fort Monroe, Virginia; 8th U. S. Army Aviation Officer, Korea; and Army Aviation Officer, Far East.

He attended the Advanced Artillery Officers Course in 1949 and the Command and General Staff College in 1957. He is both fixed and rotary wing qualified and is instrument rated with over 3,800 hours in Army aircraft.

BACK IN THE DAYS of the Model-T, running out of gas was considered a normal risk of the road. Other than minor irritations or some girl friend's reputation, little damage was caused. Today, very few automobile drivers allow their machines to run out of gas. Unfortunately, some pilots do.

The pilot of the D-model Bird Dog was on a night cross-country. He filed a flight plan estimating 3 hours and 10 minutes en route. After flying 3 hours and 48 minutes, the aircraft ran out of fuel, and the pilot bailed out. Scratch one Bird Dog.

A Seminole pilot filed a flight plan with an intermediate fuel stop. He reached the fuel stop after flying for 3 hours and 30 minutes, but elected to continue to his destination without stopping. At the destination, weather prevented an immediate approach and the pilot decided to return to his intended fuel stop. On the way he ran out of fuel and made a wheels-up landing in a wheat field. Result: $5,500 aircraft damage because one 45-minute fuel stop was skipped.

Two pilots departed in an LC-126 to practice instrument flying. Prior to takeoff, they had exchanged seats several times while installing orange plexiglass. After flying for 25 minutes, the fuel gauges indicated both tanks empty. This couldn't be right they reasoned, because the tanks were full at preflight. Five minutes later a dead engine proved the fuel gauges were right. A forced landing was made downwind, and the aircraft turned over. Betting against the fuel gauges cost $4,500.

There are more examples available, but these are enough

The Gray Hair Department is prepared by the U. S. Army Board for Aviation Accident Research staff with information from its files. Views expressed in this department are not necessarily those of the Department of the Army or of the U. S. Army Aviation School.—The Editor

Betting against the fuel gauges caused this ending

to get the idea across. The Bird Dog pilot in the first incident failed to use the wind given on his flight clearance in planning the flight. He also failed to check his groundspeed between check points. The Seminole pilot was not only trying to stretch his fuel but he was betting on the weather to remain good at his destination. It never pays to gamble with fuel or weather. The two LC-126 aviators evidently kicked the fuel strainer valve open while they were scrambling around with the plexiglass. Then they refused to believe the fuel gauges. It doesn't cost anything to land and find out what's wrong when the fuel gauges start acting peculiar.

WIRE CUTTERS

The Bird Dog pilot noted a power lag on takeoff. However, he attributed it to rapid throttle application. During the flight he selected a river bed to practice solo simulated forced landings. On the last of these the engine failed to respond with power for the climb-out. By the time the engine caught, the aircraft was very low. In the initial climb it struck three power lines. Fortunately the pilot was able to complete his climb and return to an airfield. The propeller, cowl, windshield, both wings, and a strut were damaged.

The Beaver pilot was receiving a qualification check ride. The check pilot gave a simulated forced landing at an altitude of 1,500 feet. It was late afternoon. The pilot elected to make his approach to the west, into the sun. While in the final turn, partially blinded by the sun, both pilots failed to observe power lines along the approach end of the field. The aircraft struck the wires and spun to the ground. Although the cockpit area was demolished, both pilots escaped with minor injuries.

The Chickasaw pilot noticed

Powerlines severed nose of sturdy Beaver

a group of laborers working along some new highway construction. Flying low over the site, the pilot pulled up to avoid some wires directly ahead. Letting down on the other side of these wires, he proceeded to contour fly along the edge of the new highway. Shortly after, he encountered more wires directly ahead. Collective pitch and left pedal were rapidly applied for a climb to safe altitude, but this action was too late to avoid the wires and the right front landing gear, right clam shell door, and main rotor blade were damaged.

The Sioux pilot was making an approach into a confined area. Approaching at approximately 20 feet above the ground, he felt a bump. After landing, he discovered that both tail rotor blades were damaged as a result of the tail rotor striking some wires.

These are but four of a multitude of similar accidents. All involved a surprised pilot, some unexpected wires, a fallen cake in some farm wife's oven, or an interrupted conversation on the party line. But the similarity doesn't end here. They all have the same cause factors. Either these pilots were in too much of a hurry to make a reconnaissance of the area, or they felt they knew the area so well that it wasn't necessary. Herein lies the moral of the story.

Perhaps the most experienced wire-avoiding pilots in the world are agricultural duster pilots. Older pilots commonly practice close ground examination of the arcas they are to spray or dust. If this is impractical, it's a sure bet that a thorough air reconnaissance will be conducted before the first run is made. Regardless of how many times they go back to the same field, a reconnaissance is made before each operation.

Wires are often difficult to see from the air; their poles

blend into the background or trees hide them; they follow no rules for height or direction; they may cut across at a diagonal or slope up and down. Webs of wires are strung in the most tempting places for simulated forced landings or contour flying. Wires are treacherous and dangerous, but they can be avoided!

The few extra minutes it takes to perform a high and low reconnaissance of an area are well spent. No simulated forced landing or contour flight should be without them!

TIRED PILOT

Tuesday, the pilot flew his Bird Dog 11 hours. Wednesday, he flew 7 hours and 45 minutes. Thursday morning, this same pilot was assigned to make a leaflet drop. Completing this mission, he pulled up to make a 180° turn so he could fly back and check the drop. During the turn, the engine stopped and the aircraft crashed on the left wing, cartwheeling to a stop.

This pilot was unable to remember anything from a few seconds before the crash until he found himself standing beside the wrecked aircraft. After flying over 20 hours out of 48, the amazing thing is that he remembers even starting the flight. If this was a test to determine human endurance, it certainly accomplished its purpose and proved one point—we all have limits!

It seems that no matter how long and loud the flight surgeons preach about too many flying hours and pilot fatigue, there's always someone ready to try proving them wrong. More evidence to support some old theories about candles and cakes.

MEDICAL EVACUATION

The Chickasaw was on a medical evacuation mission to transfer a patient from a civilian hospital. Its crew consisted of a pilot, copilot, and medical evacuation officer. The patient, wife of an Army officer, was to be accompanied by her husband, her six-month old son, and her mother to act as the female attendant.

Cartwheeling in a Bird Dog can be expensive

Rotor blades striking pole caused this Chickasaw to upset

Arriving over the hospital and without performing a reconnaissance of the area, the pilot elected to land on the east-west dual highway in front of the hospital. The landing was made on a crossover lane of the highway and the pilot turned the aircraft around so that the cargo door faced the hospital. In this area he was confined by telephone and high tension wires on three sides. The area to the east (downwind) was the only one free of obstructions. Immediately north of the highway was a large open field clear of all obstructions.

As the passengers were being loaded, the copilot dismounted and made a rapid ground check. When the passengers were ready to go, the copilot reentered the aircraft and informed the pilot there were wires across the highway behind them and that they would have to proceed to the east along the highway to have sufficient room for takeoff west into the wind.

While the copilot was fastening his safety belt and shoulder harness, the pilot started to taxi east into the right lane of the highway. A ground guide was not used for this taxi movement. Although aware of a utility pole to his right front, the pilot was checking to the left to be certain his left main gear would clear the island in the center of the highway. The copilot finished fastening his harness and glanced up to see the utility pole at close range. He shouted a warning to the pilot who looked to the front just as the main rotor blades cut into the pole. The aircraft rolled and crashed on its right side.

The copilot received contusions and lacerations that hospitalized him for 12 days. Both female passengers and the baby received abrasions requiring first aid. Fortunately, these were

the only injuries.

Comments on this accident are left to the reader's imagination!

HELICOPTER SUPPLY

ROTC units were in range firing positions at summer camp. An ROTC advisor, riding on the left side as a passenger, utilized a Raven to make a reconnaissance of these positions. He discovered that the units had no grenade launchers and decided to deliver launchers by helicopter. The pilot, having just met his passenger, had the impression that he had considerable experience in operational missions employing helicopters. Pilot and passenger merely had an understanding that they would fly to a given point, pick up the grenade launchers and deliver them to the waiting troops.

No delivery instructions were given the passenger by the pilot concerning the delivery method to be used. They later decided to save time by dropping the launchers, since firing was at a standstill at three separate locations awaiting the arrival of the launchers.

The first delivery was made without incident by dropping the grenade launcher to the troops on the ground while the helicopter was at a hover.

The location for dropping the second grenade launcher was in an area of tall grass. Because the launcher could be lost in the grass, the passenger attempted to throw the launcher toward personnel on the ground. By tossing across his body, with his arm high enough to clear the cyclic control, he lobbed the grenade launcher into the main rotor system. Indications were that the grenade launcher traveled out about 6 feet and up about 5 feet before being struck by the main rotor blade. The possibility of an updraft carrying the grenade launcher up into the rotor system was not considered feasible.

At the time the launcher entered the rotor system, the pilot heard a loud report and noted a silvery flash to his left. He immediately landed the helicopter and shut off its engine. Investigation revealed major damage to the main rotor blade.

As a result of this accident, it was recommended that aviators issue specific instructions and closely supervise and control the actions of those personnel involved in making helicopter drops. With a .400 hitter at bat, it never pays to chance a high pitch!